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PLANNING CONCEPTS FOR ASD INFORMATION/DECISION SYSTEMS

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PLANS DIVISION, PLANS & OPERATIONS OFFICE

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AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

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PLANNING CONCEPTS

FOR ASD INFORMATION/DECISION SYSTEMS

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Plans Division, Plans & Operations Office
January 1963

AERONAUTICAL SYSTEMS DIVISION
Air Force Systems Command
Wright-Patterson Air Force Base, Ohio

ABSTRACT

This Planning Note provides a foundation for the planning effort needed to furnish ASD with a management system which takes fullest advantage of the best tools available. The paper identifies thirteen categories of concepts pertaining to the ASD decision system in the 1965-75 time period. Each category is described and the ASD concept stated in terms which are broad enough to retain validity for an extended period of time, yet in sufficient detail to provide a preliminary basis for describing or measuring progress toward the attainment of an adequate information/decision system.

Although publication of this Note does not constitute approval by the Air Force of the findings or conclusions contained herein, there is mounting evidence that electronic information processing is going to become a major factor in the operation of the Aeronautical Systems Division. This document, therefore, is published to stimulate and encourage the exchange of ideas.

FOR THE COMMANDER

Ralph C. Lenz Jr.

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Planning Concepts for ASD Information/Decision Systems

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Foreword

Technological advance has provided the modern scientist, engineer, and manager with the electronic computer, a highly significant and sophisticated tool. Vast improvements have been made in this equipment since the first operational one was constructed. Today's computer has capacity, speed, and versatility which could hardly be visualized twenty years ago and advances during the next ten to fifteen years will be even more profound. Effective use of this tool, which is both complex and costly, requires an understanding of its potential and careful planning for its application.

Optimum use of computers is difficult to achieve. The man-machine relationship presents major problems for which there is no historical parallel. As a result, it requires major adjustments in the attitude of managers as well as demanding a completely new set of rules for design of management systems. These changes can only come gradually and as a result of a lot of effort and, probably, many mistakes. In the meantime, the managerial technology inevitably lags behind the equipment technology.

On the other hand, and despite rapid advances in computer technology, it is important to recognize that information processing equipment possesses significant limitations and is not a panacea for all the ills of management. It is expensive; it is difficult to communicate with; it tends to

be sensitive to its environment; it can retain and work with only limited amounts of data; it is not readily adaptable; and much preliminary effort is usually required before it is ready to work on a problem. Better understanding of these limitations will clarify appropriate applications and contribute to an increasingly significant role for automated information processing in ASD operations.

At this time, it is not possible to predict the details of the long term future use of computers by ASD, but it is imperative that a framework be established so that ASD can assure itself that its increased use of computers is coherent and consistent.

Planning Concepts for ASD Information/Decision Systems

INTRODUCTION

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For various reasons a discussion of computers, computational devices, and decision systems presents numerous semantic difficulties. First, of course, is the problem created by the use of the word "computer" or any of its derivatives. In this paper, reference to "computers" will adhere to the distinction made by Haley and Scott, ". . . modern usage has tended to draw a distinction between 'calculating machines' and 'computers,' the former requiring manual control for each arithmetic step and the latter having the power to solve a complete problem automatically." 1/ References which are intended to include punched card equipment, desk calculators, adding machines, etc., will be under the generic phrase of "data processing equipment."

Another word which creates some obstacles to understanding is "systems" since the term is often interpreted as an abbreviation of the phrases, "weapon system" or "command and control system." In order to alleviate the effects of this possible mental "set" on the part of the reader, the troublesome word "system" is preceded by a modifier (normally "management" or "decision") wherever used. The redundancy, although perhaps tiresome, has been found necessary to avoid confusion. An alternative would be to avoid completely the use of the word but, unfortunately, a suitable substitute has not been found or coined.

1/ A.C.D. Haley and W.E. Scott - "Analogue and Digital Computers" - Philosophical Library Inc. - 1960.

"Data" and "information" are not synonymous. In this discussion information is constituted of data which have been processed in such a way as to be meaningful and useful for decision purposes. This distinction is important for several reasons. First, "information" at one level of the decision scale often becomes "data" at a higher decision level. There are myriad types of equipment capable of handling data but only a relatively limited (although growing) number are capable of effectively transforming these data into information. Treatment of information as data for higher decisions requires increasing sophistication in equipment and in understanding how to apply it. Since the effectiveness of a manager is determined by the nature of the information he obtains and how well he uses it, the optimum manager will prove to be the individual who has best geared the use of equipment into the organization's decision system. If the manager chooses to consume his energies by converting data into information, he has reduced correspondingly his potential for effective use of the information by failing to make use of the data reduction tools which are available. To the extent that the manager can delegate responsibility for converting data into information, the manager is conserving his personal resources for the significant task of decision making.

The appearance of computers is causing significant impacts in the management area as well as in the scientific community. As is the case with most complex tools, however, much study and effort is required in order to fully assess and take advantage of the advanced technology of the equipment. Several writers have advanced the proposition that the

full potential of the computer is not being realized. Mr. Dwyer, for instance, states: "Today, electronic computer applications generally reflect a conversion of old systems rather than the development of new systems designed to capitalize on the unique capabilities of the computer." 2/ Mr. Rosenzweig says: ". . . full potential of electronic computers has not been realized in the majority of present installations." 3/ Much of the failure to achieve relatively effective use of computers can be traced to the approach which typically has been used by organizations considering partial or even complete conversion to electronic data processing. Far too often the effort has been directed toward using computers with the present system rather than recognizing the value of system redesign. Limited goals have produced limited results.

Not long ago a key official in a large industrial organization commented to the effect that the introduction of high-speed large capacity data processing equipment might quite conceivably turn out to be the most significant advance in civilization since the invention of the wheel. Why should a responsible individual compare this upstart to the discovery which has been described as the foundation of human civilization? Why does electronic processing of data open up possibilities which were not achievable or even foreseeable with manual, mechanical, or

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2/ E.D. Dwyer: "The Computer Challenge" - Navy Management Review - August 1959.

3/ Jim Rosenzweig: "The Weapon Systems Management Concept and Electronic Data Processing" - Management Science - Jan 1960, Vol 6, No. 2.

electric methods? What are some of the attributes of this equipment which already suggest the ultimate significance of automatic data processing?

First is the characteristic of speed. Probably the most popularizing feature of processing data electronically is the rapidity with which an element of data can be acted upon. The capacity to add, subtract, multiply, or divide in thousandths of a second is highly significant in the solution of involved formulae or in the treatment of masses of data. The rapidity with which the modern computer can process data staggers the imagination and the limit has not been reached since computers presently being designed will operate at speeds on the order of ten times faster than today's equipment.

The second important characteristic of this equipment is its ability to store - and have relatively ready access to - tremendous files of data. Whether the device stores the data on paper tape, magnetic drums, magnetic tape, magnetic disks, or on cathode ray tubes is not too significant at this point. The manager should know that he can materially reduce the amount of storage space he is currently using for his files and, at the same time, significantly improve his ability to "get at" the specific information he requires.

The third feature is the element of accuracy. Management today is putting its faith in data which are, to a surprising extent, invalid or only partially correct without even recognizing that serious discrepancies

exist. Typically, the blame has been put at the point of origin. As a practical matter though, the degree of inaccuracy caused by the original source of the data can normally be determined; but the trustworthiness of the data becomes progressively more suspect as it is manually summarized, adjusted, extrapolated, interpreted, and so on, for each step in the data cycle has heretofore tended to create and introduce more errors and discrepancies.

Computers provide us with several avenues for minimizing this problem of errors. One element of course, is the high degree of accuracy of the equipment itself. With the self checking features which are built into circuitry of the equipment, machine created errors are on the order of a one to a million possibility and this factor can frequently be improved upon, if desired, by providing additional checks in the machine program. If an error occurs as a result of faulty programming, the error tends to be a repetitive one which will become so emphasized as to be readily apparent in the output of the machine or which will be easily identified by spot checks. a/

Once the machine program has been "cleaned up" or "de-bugged", time and resources which were formerly spent in policing the entire data processing effort can be devoted to the data source, either for the purpose of

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a/ Caution is appropriate at this point. It is possible to have a repetitive error introduced which does not become immediately obvious through a review of the products. Normally this kind of error is of a nature which will bring the machine to a halt but there have been occasions when the machine continued to process. In rare instances such errors have been uncovered only accidentally.

increasing source data validity or to develop an accurate measure of the reliability of the data in the system. A significant reduction in error probability, then, can be achieved when manual processing is replaced by equipment processing, and errors which are introduced during manual re-processing are practically non-existent with machine processing.

A fourth feature of automatic data processing devices is known as "stored programming capability." At this point we have a grip on one of the characteristics which tend to substantiate the estimate of significance as made by our industrialist. Prior to the appearance of electronic computers, those machines which were available to assist in handling data would react once and wait for human intervention or instruction before proceeding to do the next step. The stored program now permits data to be arranged in sequence; merged with other data; numerical values added, subtracted, multiplied, and divided; percentages computed and applied; and obsolete information weeded out - each action taking place in accordance with a preconceived plan and with little or no intervention by any human - and each action taken creating far fewer errors than we have ever before been able to experience.

The fifth characteristic is a natural outgrowth of the preceding attribute. This is the capacity to modify programs automatically. There have been numerous papers written on the "ability" of computers to "learn" and there has been quite a lot of research undertaken with the objective of duplicating the human learning processes in computer circuitry and

computer programs. The technology of the equipment now exceeds our knowledge of how to use it so that today we can't take full advantage of its self-programming capability. Our ability, however, to use the equipment is growing and there is excellent reason to believe that significant breakthroughs will occur before long with the result that ultra-sophisticated programs and systems will be made available through use of the equipment for data and management system design purposes. Fulfillment of this goal will ameliorate one of the principal problems which contemporary designers face when developing a complex managerial system. In an endeavor to reach a fully integrated data system, an almost insurmountable hurdle exists today in the area of redesign. Any "minor" adjustment tends to have reactions through the entire decision system complex. Traditionally, these reactions are painfully and laboriously traced through the complete network, often consuming time and manpower far out of proportion to the benefits to be obtained. As we increase our ability to apply computers to the management system design effort it will be possible to introduce modifications in timely and economical manner and we will even be in a position to predict the value of the modification thus permitting the manager to scientifically decide whether the change should be introduced at all and, when the decision is affirmative, the most appropriate time for making the adjustment.

The sixth - and possibly most significant - capacity of modern day computers is their ability to compare values and then do further processing, the nature of which depends upon the results of the comparison. It is in this area of application that management has been least successful in taking

advantage of the possibilities of this equipment. Laxness in making fullest use of computers is the result of numerous factors. The manufacturers of computers, understandably concerned with sales, have touted the value of these machines in terms of capacity to maintain files of records, thus speaking in terms familiar to the prospective purchaser. Traditionally, functional area managers state requirements or develop systems to satisfy their specific needs without regard to the integration of their requirements into an overall management system. The systems design responsibility must be divorced from functional area attitudes in order to assure that individual system segments are compatible and effectively integrated to meet the total needs of top management. Machine technology has not yet reached the point where it is possible to construct a self-organizing or thinking machine so that higher-order-decisions are generally not subject to machine accomplishment today. It must be recognized therefore, that there is a large body of elements in the decision spectrum which is not machine susceptible. Decisions involving moral, political, or social aspects are rarely subject to pure mathematical treatment and the machine can only serve to assist the decision maker.

In a large number of instances, however, the need for a specific decision can be predicted and precise rules stated before the need for the decision arises. If management is willing to take the time and exert the mental effort necessary, many decision rules can be so stated as to permit the use of automatic equipment to make the decision, thus assuring speed, uniformity, and predictability in the decision process.

At the lower management levels of an organization, quantitative factors tend to dominate decisions and it is at these levels that electronic information processing will have its most direct and immediate impact. The effect of such equipment on the higher decision levels will, in the long run, be highly significant although often not as direct. Executives will find that they have available a wealth of quantitative information which has not heretofore been accessible. More important to the key executive may well be the ability to study the effect of alternative decisions through simulation techniques. Top managers will not be replaced by machines but will find themselves working with electronic processing equipment to improve the way in which their decision functions are performed.

In the electronic computer, then, the Aeronautical Systems Division will have a tool of tremendous versatility and capacity. It is a complex and demanding piece of equipment and its potential can, today, only be guessed at in view of rapid advances being made in the technology. In order, however, to provide the Aeronautical Systems Division with the capacity to attain the most effective results possible from equipment which is now or will be available, it is important to specify those concepts with respect to automatic data processing which are pertinent to the mission of the Division.

I. INFORMATION/DECISION SYSTEM CONSIDERATIONS

1. COMPATIBLE AND INTERACTING MANAGEMENT SYSTEMS

". . . It seems reasonably certain that the time is not far distant when we will be able to exploit the decision-making capabilities of the digital computers to a much greater extent than is now done, and when many of the more humdrum mental tasks which now take so much human time will be done by machine." 4/ Computers are providing management with a capability for obtaining information regarding related functions and areas of work to an extent far beyond the capacity of previous data processing equipment. The speed of the computer together with its ability to make comparisons (low-order decisions) and vary its actions in accordance with the results of the comparison can be effectively utilized only when the various sub-systems are designed in such a way as to be compatible with each other. "The most important feature of data processing applications is that any particular job is not a self-contained problem, but rather one phase of the company's operation, and must therefore be integrated with the system as a whole." 5/ The first concept, then, relates to compatible and interacting management systems.

The ultimate in efficient and effective use of computers can be achieved only when the management system is designed to take fullest advantage of their speed and capacity as an integral part of an on-going

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4/ Arthur L. Samuel - quoted in "Advances in Computers" - Alt, Booth, Meagher - Academic Press - 1960.

5/ Calvin C. Gotlieb, quoted in "Advances in Computers" - Alt, Booth, Meagher - Academic Press - 1960.

process with each element of the process fitting logically and fully into preceding and following elements.

2. AUTOMATIC UP-DATING OF RECORDS

The basis of the decision system exists in the raw material (basic data) which will be processed to permit extracting of the information needed for decision purposes. These data are fed into files of records which can be called upon at appropriate times to provide the information desired. Typically, the records maintained for each function, and sometimes for each operation, have been maintained separately and these records have often been modified on different time schedules, and from different sources. The effect of the resulting confusion can hardly be overstated. Financial, procurement, and supply records never matched at any point in time and were inadequate for cross-checking purposes. The ASD concept is to provide for automatic up-dating of records.

Today many files maintain much the same information. The development of compatible and interacting systems will eliminate the need for a number of those files and more rapid processing will reduce the remainder still further. It is, however, quite probable that some files will contain one or more data elements which are identical to parts of other files, and that a change to a specific element should be reflected in each of the files. Automatic data processing equipment reduces the errors encountered in manual file up-dating and can speed the up-dating process enormously.

3. IMPROVED ACCURACY OF BASIC DATA

Use of data from a single transaction for adjustment of all related files places an additional premium on confidence in the raw data. Studies in industry indicate that there is probably a serious lack of validity in data going into our files. In some areas as high as 60% of the individual records have contained errors or discrepancies. It is highly unrealistic to assume that 100% accuracy of management data can be achieved, yet many decisions are being based on just such an assumption. We do know, though, that automatic processing of data achieves tremendous reductions in errors which are currently being created subsequent to the initial introduction of raw data into the system. Automatic processing also create the climate necessary for mathematically determining the probability of error for information furnished for decision purposes. The next ASD concept, then, pertains to improved accuracy of basic data.

Increased use of automatic data processing equipment will eliminate many data errors currently generated by repetitive manual processing. The collection of raw data, however, presents an area which must be carefully scrutinized. The most error-free method, of course, is to collect the raw data as an automatic by-product of the routine operation. Since such a technique is by no means always available, it is important that the means for accumulating raw data be scientifically designed and tested. The goals of the design of any method for the collection of raw data must be: (a) use automatic acquisition of data to the fullest possible extent; (b) permit mathematical determination of error probability, and (c) facilitate machine audit (and correction) of raw data.

4. FACTORS INVOLVING MANAGEMENT SYSTEM DESIGN AND REDESIGN

One of the significant problems facing us today is the amount of time which it takes to institute a workable data system design for available equipment. "The production and delivery of a computer is a much less complex task than the establishment of a data processing system - the ultimate product mission. But if the top management, systems analysts, and manufacturers could focus on the overall product mission, the greatest long run benefit would accrue." 6/ This same problem - time - tends to limit our willingness to undertake system redesign even when the desirability of such an effort is very evident. The next ASD concept, then, is in the area of factors involving management system design and redesign.

The total problem of a data system involving effective use of automatic equipment is very complex and the design of such an involved system generally requires considerable time and meticulous attention to detail. Introduction of automatic data processing equipment directly into a manual or manual-mechanical data system rarely results in an efficient application. The data system should be specifically designed for equipment application with proper attention paid to the inevitable need for adjustment of the system to changes in the requirements of management and operations. The ultimate concept obviously involves the use of equipment to actually design the data system. Since, however, our capability to use automatic

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6/ Jim Rosenzweig - "The Weapon Systems Management Concept and Electronic Data Processing" - Management Science - January 1960, Vol 6, No. 2.)

equipment has not reached the sophisticated level necessary for such an application, the interim parameter calls for the design of each data system in such a way as to assure its flexibility and ease of redesign.

5. REAL TIME PROCESSING

With processing speed being a significant attribute of the equipment, it is inevitable that managers (and computer manufacturers) longingly consider the possibilities of "real time" processing - processing the data at the instant that the transaction itself takes place. There are undoubtedly times when real time or instantaneous processing of data is an essential element of an on-going process. Care should be taken, however, to assure that the necessity is genuine and substantial. The cost of establishing a facility which approaches real time capability tends to be high in terms of sacrifice of other potential in the equipment as well as in terms of dollars. A digital computer geared to a space vehicle guidance system might have its entire capacity devoted to continuing computations of velocity, altitude, location, etc., with instantaneous feed-back to govern guidance or speed of the vehicle. On the other hand, a computer might be programmed in such a way as to permit interruption of a processing run as a result of in-put from a remote inquiry station; returning to the processing run only when it has completed the action required by the interrupt. In the one instance, a special purpose unit has been provided to permit real time processing and the cost can be readily determined. In the other case, real time processing has been achieved by diverting the equipment from a task which it is performing - the cost of the delay can only be approximated but is nevertheless a very real cost. The ASD concepts, then, should include consideration of real time processing.

In any data system, which envisions the use of automatic data processing equipment as an integral part of the on-going physical operation, the need for rapid feed-back from the equipment to control the physical operation must be examined and if such need is found to exist, adequate provision should be made for it.

II. EQUIPMENT CHARACTERISTICS

The cost of computer equipment is high. Even when it is rented, there is normally a significant capital expenditure in terms of money (to provide an adequate location for efficient operation) and in terms of time (necessary to design the system to make most effective use of the equipment).

6. FLEXIBILITY OF EQUIPMENT

Advances in both general and special purpose computers have occurred at a rapid rate with major improvements in both capacity and speed. Concurrently there have been significant reductions in equipment size and in requirements for power and for air conditioning. There are a number of reputable firms manufacturing computers, each touting the virtues of its own products and, unfortunately, often over-simplifying the difficulties involved in making computer applications. Since most computers are available in a variety of configuration, especially with respect to peripheral gear, the selection of the most effective computer becomes a proposition of major proportions. It is not possible today to visualize all appropriate uses of equipment. It may, for example, be highly desirable to couple a piece of computational gear with a photographic reproduction device. Second, to assure that we can always select the best equipment for our purposes it is important that the "machine language" used be universal so that it is possible for one machine to "talk to another" even though different manufacturers are involved. Third, selection of equipment will be governed in large part by expandability of capacity so that new

applications can be made without concern that the equipment will become overloaded. The ASD concept involves flexibility of equipment.

"Manual and machine elements of the data-processing system must be flexible and not rigid if it is to satisfy the needs of management." 8/ Advances in equipment technology have significantly reduced the types of applications which justify the use of special purpose equipment. Competent programming will permit the use of general purpose machines for many exotic problems which formerly required the design of special circuits and gear. It is anticipated that this trend is a continuing one and hence selection of equipment is to include emphasis on versatility. Computer equipment should be susceptible of expansion, preferably with respect to internal memory as well as with respect to peripheral equipment. Extensive and effective "software" - standard programs, English language compilers, mathematical formulae translators, etc., - is a must, both to shorten the time required to put a management system on the computer and to increase the range of applications of the equipment.

7. REMOTE INQUIRY CAPACITY

Whenever any managerial or administrative system proposes the use of central files and records, the objection is raised that such centralization makes it difficult to "find what you want" and that physical separation tends to reduce the usefulness of the files. Experience with computers has proven the desirability of, in effect, maintaining "central

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8/ Milton Stone - "Data Processing and the Management Information System" from "Data Processing Today: A Progress Report" - AMA Management Report Nr. 46 - 1960

records." The problem of identification of the record desired tends to be solved automatically because of the precision with which the equipment receives its instructions and the related need for complete standardization of input formats. The problem of geographical separation remains, however, and leads to the next ASD concept which pertains to remote inquiry capacity.

Increasing automation of data handling, and especially the tie-in of automatic equipment into the day-to-day operating routines of ASD, will constantly raise the question of the appropriateness of decentralizing automatic data processing equipment. A completely integrated system would render such an approach highly inadvisable because of the cross-relationships which will exist between various data elements and records. It is probable that the 1965 - 75 period will see increased centralization of files and records. The answer to the desire of functional areas for self service with respect to equipment will be provided through the carefully considered use of remote inquiry stations. Care must be taken to assure that the interrupt privilege of such stations is controlled so that undue interference with main frame runs does not occur.

8. BETTER DISPLAY TECHNIQUES

Advances in computational equipment and techniques are continuing and significant. Up to the present time management has relied almost entirely on display of data and information in the form of written or printed reports and summaries. Research in other methods of display is showing a great

deal of promise. The present techniques may continue to predominate but there are many occasions when some other technique would be preferable. The related ASD concept is better display techniques.

The paucity of material in information processing literature on the subject of display devices and techniques is unfortunate. Typically, data processing has involved the preparation of numerous printed reports. Too often management has accepted such reports as the total potential of the data system, remaining oblivious to the very real possibility that other techniques are available which might meet management's requirements much more adequately. Information achieves value only when it is presented so as to support a decision which must be made or an action which must be taken. To a large extent, the usefulness of the information becomes a function of the way in which it is presented. Reports are only one display form. The value to management of more imaginative display devices and techniques must be recognized. Consideration will be given to coupling display devices to remote inquiry stations.

III. APPLICATION AND ORGANIZATION ASPECTS

"Improvement in management techniques will be more important than technological advance to the success of companies . . . While scientific progress will continue to be important, pressures on cost, reliability, quality and on-time delivery are placing a premium on effective management." 2/

9. USE OF EQUIPMENT TO SUPPORT THE SCIENTIFIC AND ENGINEERING EFFORT

Electronic computers were originally visualized as tools for the scientific community - - especially suitable for the solution of involved formulae and equations. Rapid improvements in equipment have heightened its usefulness in this environment. Continuing exploration of application techniques including increased use of analog computers and the coupling of analog devices to digital equipment are providing scientists and engineers with a tool of utmost significance. This has led to the next ASD concept which provides for use of equipment to support the scientific and engineering effort.

More and more the scientists and engineers are finding the high speed and versatility of such equipment essential to the solution of many sticky problems. The Aeronautical Systems Division has been in the forefront of users of such equipment for several years and the use of available equipment has been constantly increasing. Computers are being used to read and convert test results and to provide the answer to the need for mass data

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2/ Stephen F. Keating, Executive V.P., Minneapolis Honeywell - quoted in Aerospace Management, Feb 1962.

reduction. All personnel should be alert to other applications using techniques which have been tested and proved as well as to potential applications. Much study is currently going on in the area of machine translation and machine abstracting. It is anticipated that major advances in these areas will provide tremendous pay-off in enhancing the capability of our technical personnel to keep abreast of advances in their own and related fields. At this point, it is not possible to determine whether special equipment will be required for such information retrieval but there can be no question but what there will be vast growth in information retrieval capacity and that such growth will have significant impact on the ASD environment.

10. USE OF EQUIPMENT AS A MANAGEMENT TOOL

Recognition of the possibility that computers could be effectively applied as administrative and managerial aids has been reached subsequent to their conception as a tool of science. The great increases in memory capacity, the development of peripheral gear, and advances in programming techniques have all constributed to make these devices major tools of management. Today the technology of the equipment has surpassed our knowledge of how to make most effective use of it. The next ASD concept, therefore, concerns use of equipment as a management tool.

The ultimate value of automatic data processing equipment will be in large part measurable by the extent to which it is used to make management-type decisions or to high-light specific problems for which decisions are required. It is obviously not probable that top management will ever be able to delegate to electronic computers the responsibility for making

decisions involving political or broad policy aspects. When such determinations, however, have been man-made, the computer can make a surprising number of the lower-echelon decisions provided that the necessary effort has been made to state the controlling factors which lead to such decisions. At the same time, the computer can provide a feed back to top management which will permit continuing assessment of the appropriateness of the original decision. More and more our systems are going to be designed so that the computer becomes an integral part of our day to day operations. The results will not always be pleasant since the computer will tend to show up our failures without the saving grace of glossing over them. We will be operating in a new frame of reference and will have to adjust our thinking accordingly.

11. MANAGEMENT REORIENTATION AND EDUCATION

A number of writers in discussing the application of computers to management and decision systems have indicated the belief that a problem may exist in failure of the management people themselves to recognize the importance of and provide for proper use of this tool. "We should worry less about the mechanical incompatibility of one computer with another computer, and worry more - even exclusively - about the growing incompatibility of computers and managers." 10/ Again: "There can be little doubt that computers will profoundly affect the ways in which we learn, think, build other computers, and plan the operations of our society." 11/ Or: "With instantaneous feedback

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10/ E.B. Dwyer - "The Computer Challenge" - Navy Management Review - August 1959.

11/ Walter R. Rosenblith - "Social Consequences of Change" - Daedalus Journal of Academy of Arts & Sciences - Summer 1961.

flagrantly spotlighting lack of foresight, the decision-maker must now define his objectives accurately. There can be no 'playing for time', for unsound decisions boomerang immediately. The 'Think' signs so prominent in EDP offices are the handwriting on the wall for management by intuition and 'flying by the seat of the pants.' One hard boiled EDP executive, refuting criticism that computer systems are 'inflexible', stated, "Flexibility" just means that the fellow wants to change his mind when he shouldn't. He is doing some after-the-fact thinking.'" 12/

All signs point to the fact that computers are in the process of creating a revolution in our ways of doing business. The management levels must be made aware that this revolution is going on and then must be trained to work with and take full advantage of the tools which are generating the changes. "I think that when memories are large enough to store all signals needed and generated for an entire task, the situation will be changed qualitatively. For human beings would no longer be used as components which are, in fact, even in the humblest tasks, error correcting mechanisms of very high order. Thus one can hardly extrapolate from present experience of machines as 'clerical aids' for humans, to the fully automatic system." 13/ The next ASD concept relates to <u>management reorientation and education.</u>

The ability to work effectively with computers is not easily acquired. The difficulty is enhanced at present because of the lack of preciseness with

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12/ Ida R. Hoos - "Sociological Impact of Office Automation" - Management Technology (TIMS) December 1960 (Vol I, Nr. 2)

13/ R.A. Fairthorn - Symposium on the Influence of Very Large Memory Designs and Capabilities on Information Retrieval - Proceedings of the International Conference on Information Processing (P482-UNESCO) - Jun 1959

which it is possible to predict our future management systems and techniques. It is nevertheless imperative that our future top managers start now to develop the familiarity with the requirements of automated data processing which will permit them to operate well regardless of the characteristics which automated management systems may evidence. As more and more of the less complex decisions are made automatically, the opportunity to receive practical experience in decision making will be increasingly limited. There are a number of studies currently underway which are designed to provide a much clearer understanding of decision processes, so that here, too, formal training can be used to substitute for practical experience. The implications are clear, however. Management will progressively become less of an art and more of a science with inevitably increasing emphasis on specialized formal education.

12. ORGANIZATION STRUCTURE

The structure of an organization which is increasing its use of high speed electronic computers inevitably must be examined for the answer to two specific problems - (a) the design of systems using computers and the operations of the computers as a significant and integral part of the management process poses the question of location of this system design function in the organizational hierarchy, and (b) the adaptation of our way of doing business to a largely computerized system requires that the basic organization philosophies be carefully scrutinized and re-evaluated. "The changing character of the company undergoing automation reflects a dynamic situation. Static relationships among organizational variables do not prevail. One may

well ask whether explicit recognition of automation in organization theory calls for the introduction of another variable or whether what is needed is a significant extension of organization theory. Certainly the accepted models can no longer be considered adequate." 14/ The ASD concept pertains to organization structure.

The advent of computers, their increasing capacities, and our increasing ability to use them, inevitably mean that our current ways of doing business are going to undergo significant changes. Since one of the factors governing the organization structure is the way in which business is done, the organization structure of the Aeronautical Systems Division will probably undergo major changes in order to provide for most effective use of these electronic devices. The most likely results include the reduction both in number of management levels and in ratio of supervisors to persons supervised. It is also likely that office files will be materially reduced since advanced information retrieval systems will provide,at a central location,ready availability of any files desired. Remote viewers and/or reproducers located at strategic points will provide the easy access represented today as a significant aspect of office files.

13. CHARACTERISTICS OF PERSONNEL

Regardless of the extent of automation, the human element is going to play a fundamental role in any automated management system. It is apparent

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14/ Ida R. Hoos - "Sociological Impact of Office Automation" - Management Technology (TIMS) Dec 1960, Vol I, Nr. 2.

...ever, that automatic data processing equipment will create a demand for personal capability which is not required by today's business methods. The need to work with such a sophisticated tool will tend to preclude the present broad sources from which management personnel are selected. The next ASD concept concerns characteristics of personnel.

The ASD automated management system will emphasize the current manning trend toward higher percentages of technically trained and qualified personnel. Qualifications for management positions will become more specific and more stringently applied. It is probable that sabbaticals for management personnel will become more common and possibly even required, for there is probably no better technique by means of which the Air Force can maintain its managerial capabilities on the high level required.

SUMMARY

This planning note advances the proposition that developments in the field of information processing will ultimately have a much greater impact on management than is currently generally anticipated. Among the computer characteristics which lead to this conclusion are speed, file storage capacity, accuracy, stored programming capability, automatic program modification, and ability to compare values.

The concepts identified in this document are to be used as guide lines for the development of the future ASD information and decision system. The concepts specifically discussed include: (1) compatible and interacting systems, (2) automatic up-dating of records, (3) improved accuracy of basic data, (4) factors involving system design and redesign, (5) real time processing, (6) flexibility of equipment, (7) remote inquiry capacity, (8) better display techniques, (9) use of equipment to support the scientific and engineering effort, (10) use of equipment as a management tool, (11) management reorientation and education, (12) organization structure, and (13) characteristics of personnel.

The relative importance of the concepts is independent of order of treatment in this document. It is anticipated that the significance of any item will vary with time and, as a practical matter, proportionate influence will become a function of problems encountered rather than an absolute statement of relative importance.

The Aeronautical Systems Division is on the threshhold of significant changes in its management or decision systems and these changes will result in major adjustments to its organization pattern and management personnel selection methods as well. Logical analysis and careful planning provide the surest protection against the confusion and reduced effectiveness which tend to become prevalent during such times of major transition.